

New Technique for Visualizing Unsteady Flow

David Kao, Han-Wei Shen

A new technique for accurately visualizing time-varying phenomenon in unsteady flow fields has been developed at Ames Research Center. The resulting images captured through the Unsteady Flow Line Integral Convolution (UFLIC) technique reveal complicated flow behavior and help scientists detect important flow features for computational fluid dynamics analysis.

UFLIC employs a new algorithm that takes into consideration the time-variable and flow patterns from previous time steps. In unsteady flows, there are no well-defined flow lines because the flow is dynamic, and particles can advance to new locations easily. The UFLIC algorithm uses a time-dependent particle-tracing scheme to trace flow textures.

This time-dependent algorithm uses the original Line Integral Convolution technique as its underlying form. To model unsteady flow, it uses a successive feed-forward convolution method that maintains coherence between animation frames and a time-accurate value-depositing scheme that models local changes in flow. The feed-forward method does not create each successive frame from the original, but creates it with the previous frame's output to ensure that consecutive frames are highly coherent. Time-accurate value-depositing ensures that as the algorithm repeatedly computes the evolution of pathlines, the pixels involved advance only in a forward pathline direction—thus reflecting physical reality, because particles in flows cannot move backward in

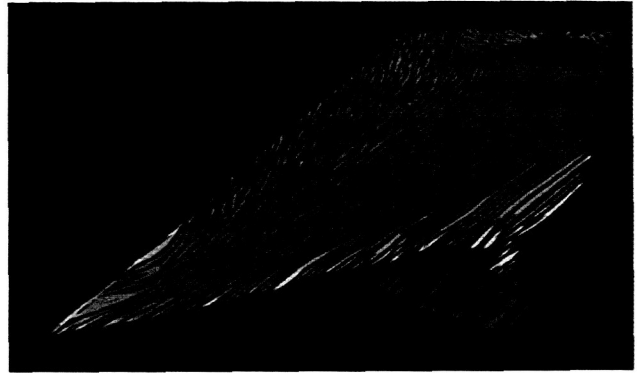


Fig. 1. Surface flow on a tail of a F/A-18 jet.

time. In addition, by using a high-pass filter, image clarity and texture are improved.

The figure shown is the surface flow generated by UFLIC using a tail of the twin-tailed F/A-18 jet. At a high angle of attack, the flow is highly unsteady, and vortex bursting is frequent along the leading edge. The velocity magnitude changes rapidly along the leading edge, which indicates cycles of vortex bursting. The results generated clearly show unsteady flow patterns and highlight flow evolution.

Point of Contact: H-W. Shen
(650) 604-4451
hwshen@nas.nasa.gov